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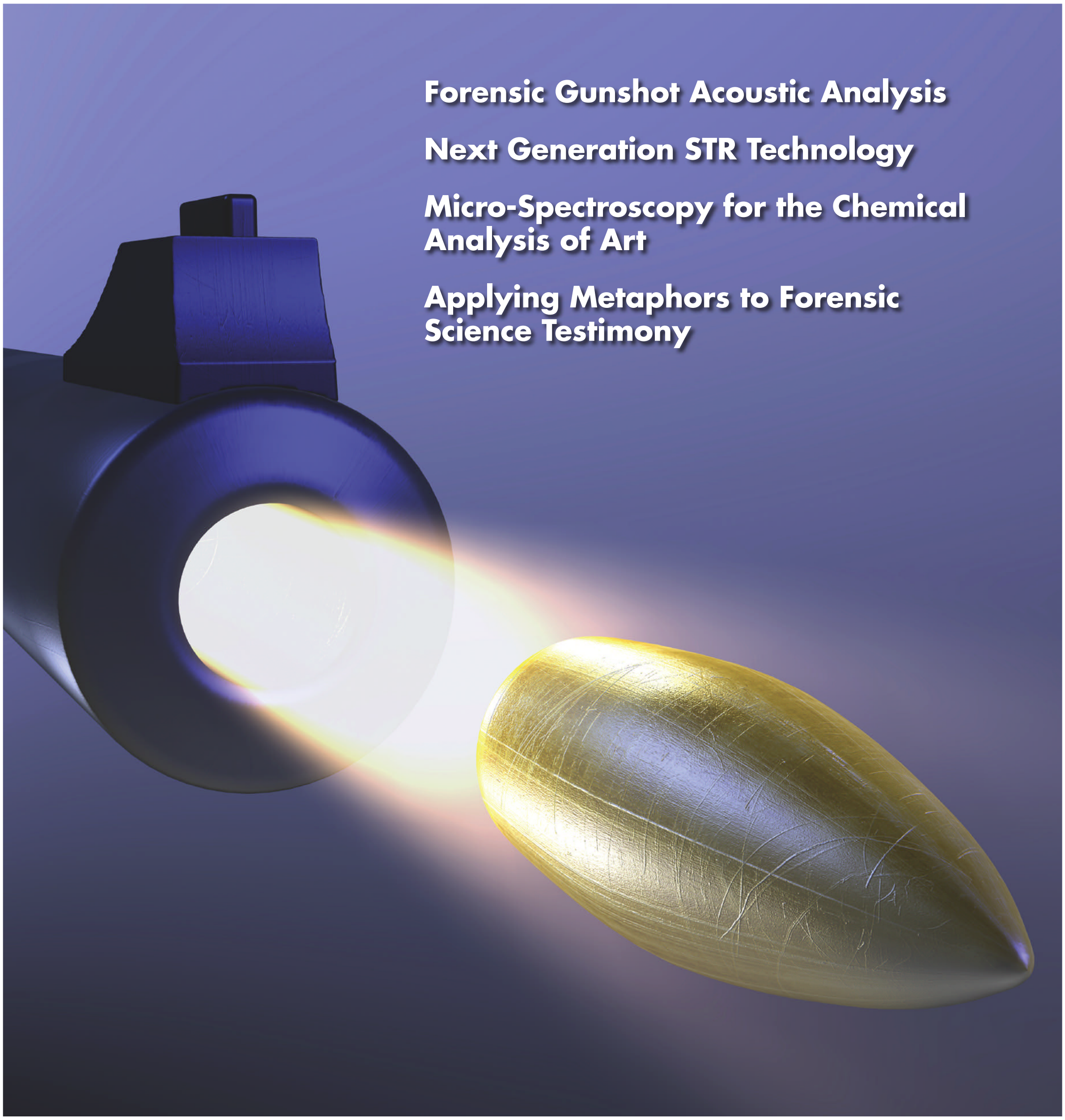

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from the editor

Progress through Cooperation

In a recent symposium and feature article in its weekly newsmagazine, the American Chemical Society (ACS) highlighted the role of the Innocence Project in “challenging improper use of DNA testing and other elements of forensic science” helping to free nearly 300 wrongfully convicted prisoners (http://cen.acs.org/articles/90/i37/Forensic-Science-Innocence-Project.html).

The symposium sought to bring together two groups who have often found themselves at odds: forensic scientists and the Innocence Project. Of course, this tension may not be unmerited, when “Research conducted by the Innocence Project suggests that [while] the number one contributor to wrongful convictions is eyewitness misidentification, number two—involved 45% of the time—is faulty forensics, which the Innocence Project defines as testimony that isn’t scientifically vetted, exaggerated testimony, and forensic misconduct.”

“I think the Innocence Project underestimates bad lawyering as a cause of wrongful convictions,” chemist Jay A. Siegel, a longtime forensic scientist and adjunct professor at Indiana University-Purdue University Indianapolis told the ACS. “Prosecutors may withhold evidence that could exonerate a defendant, and defense teams may not be trained to mount an argument against inappropriate testimony,” he explained.

The point, however, may not be the source of the animosity, but rather the progress we may accomplish if symposia like the one the ACS sponsored open a constructive debate between these two factions.

News of the troubled St. Paul Crime Lab and the closing of the Massachusetts Crime Lab bring back the discussions that began with the publication of the NRC report questioning the state of forensic science (Strengthening Forensic Science in the United States: A Path Forward). When we ourselves are questioning the validity of some of our techniques and searching for answers to the controversies that are plaguing crime labs around the country, can we blame an outside organization for doing the same? Wouldn’t we accomplish more by opening discourse into the best ways to overcome these obstacles and strengthen our criminal justice system? After all, it is forensic science and its advancements in DNA analysis that have allowed the Innocence Project to so successfully overturn most of those wrongful convictions. And ultimately, don’t we all want the same thing: criminals behind bars and innocents free to live their lives?

So what are our steps forward? How can we achieve this shared goal?

Experts who spoke with the ACS had mixed opinions about the NRC report, but agreed that education and accreditation were key. **–Rebecca Waters**

Corrections

In the August/September issue, the article “The New Face of Forensic Science” was written by Susan Halla and Keith Whittle.

In “Easy Reporting of Hard DNA: Computer Comfort in the Courtroom” Figure 4 was erroneously run twice. You can view the corrected Figure 5 at www.forensicmag.com/article/easy-reporting-hard-dna-computer-comfort-courtroom.

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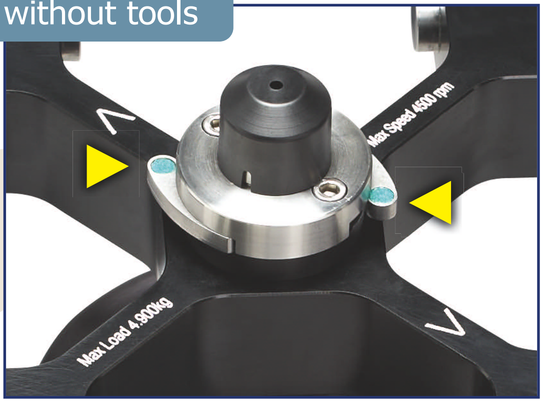

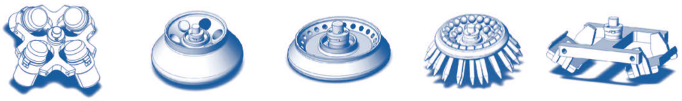

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the dna connection

Chris Asplen

“Much Harm?”

On July 30th of this year, the constitutional question of arrestee DNA testing came a lot closer to getting resolved. In what I am told by experienced Supreme Court watchers is a fairly unusual ruling by the Court, Chief Justice John Roberts, stayed the judgment in the case of *Maryland v. Alonzo Jay King, Jr*. It appears that *King* may well be the case upon which the Court determines whether law enforcement can take a biological sample from an individual arrested for, but not yet convicted of a crime.

In 2009, police arrested Alonzo Jay King, Jr., for first-degree assault. When, pursuant to Maryland law, personnel at the booking facility collected King’s DNA, they found it matched DNA evidence from a home invasion, masked intruder, gun to the head rape committed in 2003. Relying on the match, Maryland charged and successfully convicted King of, among other things, first degree rape. A divided Maryland Court of Appeals overturned King’s conviction, holding the collection of his DNA violated the Fourth Amendment because his expectation of privacy outweighed the State’s interests. That decision immediately halted Maryland’s collection of DNA from otherwise qualifying individuals—suspects arrested for violent crimes. Maryland applied for a stay of that judgment pending the Supreme Court’s disposition of its petition for a *writ of certiorari*.

While often times the standards set forth in legal opinions are decipherable only by those with a law degree and significant legal experience (Perhaps made intentionally confusing so as to justify our fees!) the standard as set forth by the Chief Justice on this issue is actually pretty easy to grasp. And I think it’s pretty encouraging for those who think identifying suspects and exonerating the innocent sooner rather than later is a good idea. It’s basically a three pronged test to stay an order issued by the lower court. To warrant relief, Maryland had to demonstrate 1) “a reasonable probability” that the Court would grant *certiorari*, 2) “a fair prospect” that the Court would then reverse the decision below, and 3) “a likelihood that irreparable harm [would] result from the denial of a stay. And it only took three pages for Roberts to find on behalf of Maryland and allow the State to once again start collecting DNA from arrestees.

Regarding the probability that the Court will ultimately grant *certiorari* and hear the case, Roberts points out that the Maryland court decision conflicts with numerous decisions from around the country including the U. S. Courts of Appeals for the Third and Ninth Circuits as well as the Virginia Supreme Court, which have upheld statutes similar to Maryland’s DNA Collection Act. (See *United States v. Mitchell*, 652 F. 3d 387 (CA3 2011), cert. denied, 566 U. S. ___ (2012); *Haskell v. Harris*, 669 F. 3d 1049 (CA9 2012), reh’g en banc granted, 2012 WL 3038593 (July 25, 2012); *Anderson v. Commonwealth*, 274 Va. 469, 650 S. E. 2d 702 (2007), cert. denied, 553 U. S. 1054 (2008); see also *Mario W. v. Kaipio*, 2012 WL 2401343 (Ariz. 2012).) Given the extent to which the split implicates “an important feature of day-to-day law enforcement practice in approximately half the States and the Federal Government” it seems Roberts had little difficulty determining that the Court would probably hear the case. He went on to acknowledge that the Maryland decision “has direct effects beyond Maryland: Because the DNA samples Maryland collects may otherwise be eligible for the FBI’s national DNA database, the decision renders the database less effective for other States and the Federal Government.”

When it came to the likelihood that the Supreme Court would reverse *King*, Roberts was similarly convinced that the second prong of the test for vacating the Maryland judgment was met. This analysis however was shorter, more to the point, and with language that I for one really liked. In establishing that the second prong of the test had been met, Justice Roberts simply wrote, “… given the considered analysis of courts on the other side of the split, there is a fair prospect that this Court will reverse the decision below.” The “considered” analysis. I liked that perspective. In other words, all those other decisions by other courts were pretty well thought out. He at least (there are a few other members of the Court that need to be convinced…) seems to be leaning toward reversal.

The third part of the test for staying the Maryland decision halting arrestee testing has me a little fired up.

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Not because of Justice Roberts' rationale or approach to the test. While there is a standard legal argument set forth previously by Chief Justice Rehnquist that, "[A]ny time a State is enjoined by a court from effectuating statutes enacted by representatives of its people, it suffers a form of irreparable injury," Roberts went beyond that argument. The current Chief Justice recognized that there is, "in addition, an ongoing and concrete harm to Maryland's law enforcement and public safety interests." Citing the fact that since 2009—the year Maryland began collecting samples from arrestees—to 2011, "matches from arrestee swabs [from Maryland] have resulted in 58 criminal prosecutions." He concluded from these facts that, "Collecting DNA from individuals arrested for violent felonies provides a valuable tool for investigating unsolved crimes and thereby helping to remove violent offenders from the general population. Crimes for which DNA evidence is implicated tend to be serious, and serious crimes cause serious injuries. That Maryland may not employ a duly enacted statute to help prevent these injuries constitutes irreparable harm."

While predicting the outcome of Supreme Court cases is a hobby I'd rather not engage in, this all seems pretty positive to me. We are at least starting in a position in which, on three major issues necessary to resolving the constitutionality of arrestee testing, the Chief Justice leans toward a conclusion of constitutionality. In short, "Yes, this is important enough for us to consider. Yes, there is a likelihood that our finding will be consistent with those other Courts that have seriously considered the issue and found it to be constitutional. And yes, there is a government interest here in the prevention of crime." It all sounds quite encouraging—again to one predisposed to believing that solving violent crime, thereby preventing future violent crime and protecting the innocent to the best of our ability is a good thing.

But lest we get too far ahead of ourselves, enter the *New York Times*.

On August 5, shortly after the Supreme Court stay was granted, the *New York Times* printed an editorial addressing the *King* decision and pending application before the Court. While advocating for the Court to take up the issue of arrestee testing constitutionality in order to resolve the important Fourth Amendment implications, it disagreed with the Chief Justice's decision to stay the lower Court's order. And the rationale? Because "As he (the Chief Justice) noted, of the 10,666 DNA samples Maryland collected last year from people arrested, fewer than 10 led to convictions, less than one-tenth of 1%. That tiny number makes it difficult to conclude that Maryland would suffer much harm if it were prohibited from

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taking DNA from people who had not been convicted.”

Wow. Seriously? When I first read the editorial, I merely disagreed with the position the *Times* took. But as I reread it and as I digested the actual language used by who I assume are a pretty bright group of people, I actually became pretty outraged. Maryland wouldn’t suffer “Much harm”?

Now I could argue that the *Times* is wrong and even disingenuous with its analysis of the numbers. While the number of convictions at this time is 10, the actual number of arrests because of arrestee testing was 58. We don’t know how many cases have yet to wind their way through the system. The *Times* also fails to acknowledge that there is a tremendous value to victims in the mere fact of an arrest. Old cases wind up without convictions for many reasons including those that have nothing to do with a suspect’s actual innocence. Witnesses disappear, victims choose not to relive the horror of their nightmare in a court proceeding after having moved on, defendant’s die, deals are cut. The *Times* also fails to acknowledge that, of those “10” convictions, the important number isn’t really 10. The important number is 10 + whatever number of crimes we have prevented by those convictions. These suspects are recidivists. That’s why they are in the system.

I could argue the numbers more, but I won’t. Because I think the bigger issue is, which of those 58 victims comforted by the arrests or which of the 10 victims vindicated by the 10 convictions wasn’t worth “much.” Did the victim in *King*’s original 2003 case, the one where she was raped in her home with a gun to her head, not suffer “much harm?” Which of the future victims, raped, burglarized, maybe murdered because their perpetrator was cut loose at arrest, never DNA tested, and then disappeared into the night—not really interested in going to trial—isn’t worth “much?”

The *Times*’ attempt to minimize the cost of victimization and the value of crime solving and prevention is pretty shocking. If you want to argue cost benefit analysis in the context of the application of broad constitutional rights, I get that. In fact, that will be part of the Supreme Court’s analysis. But to trivialize numbers which in fact are not just numbers but represent real individuals who were raped or murdered isn’t some high minded constitutional analysis. It’s just callous and wrong. What next? Considering whether or not rapes themselves are “legitimate?”

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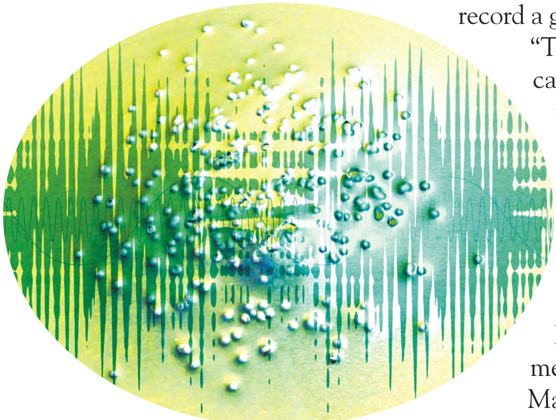
Forensic Gunshot Acoustic Analysis is Heating Up. Don't Get Burned

Gunshot acoustics hold plenty of investigative promise, but analysis can be difficult even for experts.

Douglas Page

If someone fires a weapon in the Federal Reserve Bank in San Francisco, a gunshot detection system instantly locks all security doors, trapping the shooter inside. In metro areas of cities like of Tucson, Los Angeles, and elsewhere, when a shot is fired, within one second of weapon discharge acoustic sensors stationed in strategic urban locations pick up the sound, automatically determine range and bearing, then notify authorities.

Both systems are examples of the role gunshot acoustics are beginning to play in law enforcement and forensics. Forensic gunshot acoustic analysis doesn't stop with sensor networks. Forensic acoustic experts are looking at ways to exploit the proliferation of mobile recording devices for potential forensic gunshot acoustic evidence that may lurk in the audio files of cell phones and tablets that happen to record a gunshot.



"The ubiquitous availability of audio-capable mobile devices indicates that audio evidence will more frequently be part of forensic investigations," said gunshot acoustics expert Robert Maher, the head of Montana State University's Electrical and Computer Engineering department. Maher first became interested in forensic gunshot acoustics after a conversation with a defense attorney regarding a who-shot-first question based on an emergency call center recording. Although that particular case did not hinge on audio forensic analysis in the end, it did pique Maher's interest enough to perform a series of scientific measurements. He is now a recognized expert in the field.

Maher said that under the right circumstances, recordings of gunshots can potentially tell investigators who shot first or where the weapon was located when discharged. But factors such as microphone quality and angle and direction of the weapon's muzzle can change the way a gunshot sounds in a recording.

Forensic investigators can reach wrong conclusions if they fail to understand the impact of these variables.

Calling the Shots

For many years, gunshot acoustic research was largely restricted to military, proprietary, or shooting range noise-abatement arenas. Little objective information found its way into open scientific literature for use by the audio forensics community. That seems to be changing. Maher has published several papers on forensic gunshot acoustics, including "Deciphering gunshot recordings" (Proc. Audio Engineering Society 33rd Conference, 2008) and "Acoustical modeling of gunshots including directional information and reflections" (Proc. 131st Audio Engineering Society Convention, 2011).

There is forensic promise, and investigative peril.

A recent FBI-sponsored study ("An introduction to forensic gunshot acoustics," 162nd Acoustical Society of America, 2011) illustrates the complex nature of forensic gunshot acoustic analysis.

Steven Beck, principal scientist at BAE Systems, along with FBI agents Hirotaka Nakasone and Kenneth Marr, performed gunshot acoustic studies in a controlled environment by placing microphones at a

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range of angles and distances from each blast in order to capture the sound pattern of a single round from multiple points of view. Gunshots produce two different sounds—a "bang," caused by rapid expansion of gasses that push the bullet through the barrel, and a "crack," caused by shockwaves in the air made by supersonic bullets.

The FBI used several different types and models of firearms, along with high-quality recording equipment, and multiple microphone placements relative to the firearm in order to vary range and azimuth angles. While it's true that gunshot recordings that end up in the hands of forensic analysts are created in far less ideal conditions, Beck said analysts need to understand the underlying acoustics of impulse sounds, and then know what variations can occur and how the recording conditions can affect the signals.

According to Beck, examination of the waveforms showed that the pristine recordings match closely with theoretical models, but there were a number of unexpected findings.

One surprise the Beck team found was how important the angle of the gun was to the sound signature, or waveform, caught by the microphones. According to this research, a shot fired into the air produces a wildly different waveform from one fired in the direction of a recorder, even when both shots came from the same gun. Likewise, a heavy rifle blast fired at a great distance from the microphone can produce a sound signature that is almost indistinguishable from one produced by a smaller, lighter gun fired at close range.

> "A shot fired into the air produces a wildly different waveform from one fired in the direction of a recorder."

There was another surprise—a bonus "bang" caught by recorders positioned at 90-degree angles to the barrel. The Beck team traced this sound to gasses leaking and expanding out of the side of certain types of firearms. This means investigators could potentially exploit this extra "bang" to identify the direction of the weapon from the recording device.

Current Directions

Maher said current gunshot audio analysis is concerned with three specific issues.

First, as found by the FBI study, there is increasing awareness that the acoustics of gunshots depends significantly upon the orientation of the firearm with respect to the recording device. Maher said that while many investigators assumed muzzle blast from a firearm was an omnidirectional impulse, more recent work has shown that sound level and waveform details vary greatly as a function of azimuth.

Maher said in another paper ("Directional aspects of forensic gunshot recordings," Proc. Audio Engineering Society 39th Conference, 2010), it is important for audio forensic examiners to recognize that the difference in level and waveform details between on-axis and off-axis recordings of the same firearm are often significantly greater than the difference between two firearm types at the same azimuth.

"This can have an important effect upon deducing the firearm type from a recording, especially if the orientation of the firearm with respect to the microphone is not known from some other source of information," he said.

The second important area of gunshot audio analysis pertains to the effects of mobile device audio systems on the recorded waveform—particularly perceptual audio coders like MP3 and digital speech coding systems used in cell phones.

Maher said if the mobile device is located near the shooting position, the high level sound of the gunshot will typically overload the microphone, input amplifier, and related electronics, resulting in a severely clipped and distorted waveform. Then this distorted gunshot signal is presented to the device's audio coding system, which is usually a speech coder designed to represent intelligible speech, not gunshots and highly distorted waveforms.

"Thus, interpretation of gunshot acoustic evidence that has been passed through a cell phone's audio system is an area in need of further research," he said.

Maher said the third issue is to determine the firearm type and ammunition based on acoustic evidence alone. The big issues are to ascertain the orientation of the gun and dealing with the quality and integrity of the audio recording system.

"In situations where a relatively pristine recording is obtained there may be opportunities to identify useful forensic features from the gunshot recording, but in most real-world cases the quality of the recorded waveform will be poor," he said.

Still, in situations where the recording device is sufficiently far away from the firearm that the signal does not overload the recorder, Maher said it is feasible to determine the relative timing of the initial gunshot and any significant acoustical echoes caused by reflecting surfaces nearby.

"If more than one recording is available, such as multiple devices in different locations capturing the same event, it may be feasible to reconstruct the most plausible location of the firearm and its orientation," he said.

Douglas Page *writes about forensic science and medicine from Pine Mountain, California. He can be reached at douglaspage@earthlink.net.*

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Tim Schellberg, Nicola Oldroyd, and Lisa Lane Schade

Global DNA Databases Expand Loci Sets to Optimize Capabilities

Nearly 18 years have passed since the United Kingdom's Forensic Science Service announced it had started the world's first nationwide DNA database of criminal offenders. The UK database program became an instant crime fighting success and by the turn of the millennium, the United States, Australia, New Zealand, and multiple countries in Western Europe had also moved forward with establishing national DNA database programs.

Like the United Kingdom, most of these early adopters built their programs primarily to solve crimes within their own borders, using limited loci and with limited focus on international loci interoperability. To compound this, they designed their DNA databases to search relatively small subsets of the criminal populations, which negated the need for larger loci sets.

As these countries implemented their programs, forensic scientists and police officials began to question why crime scene samples were not also being searched internationally, especially in those countries within the same region. Several studies have shown that cross comparing international databases significantly increase hit rates in certain circumstances. However, the lack of international loci standards among the early adopters made international sharing onerous, as most of the programs were not compatible.

The European Union—where criminals were able to move freely across borders to commit crimes—was the first government agency that aimed to resolve this issue. In 2005, it passed the Prüm Treaty that eventually resulted in the establishment of infrastructure to support an EU-wide network

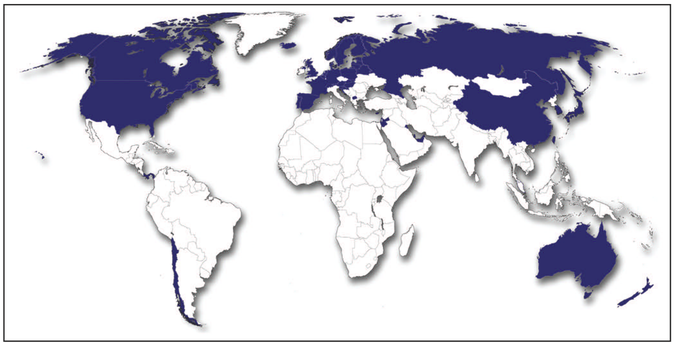
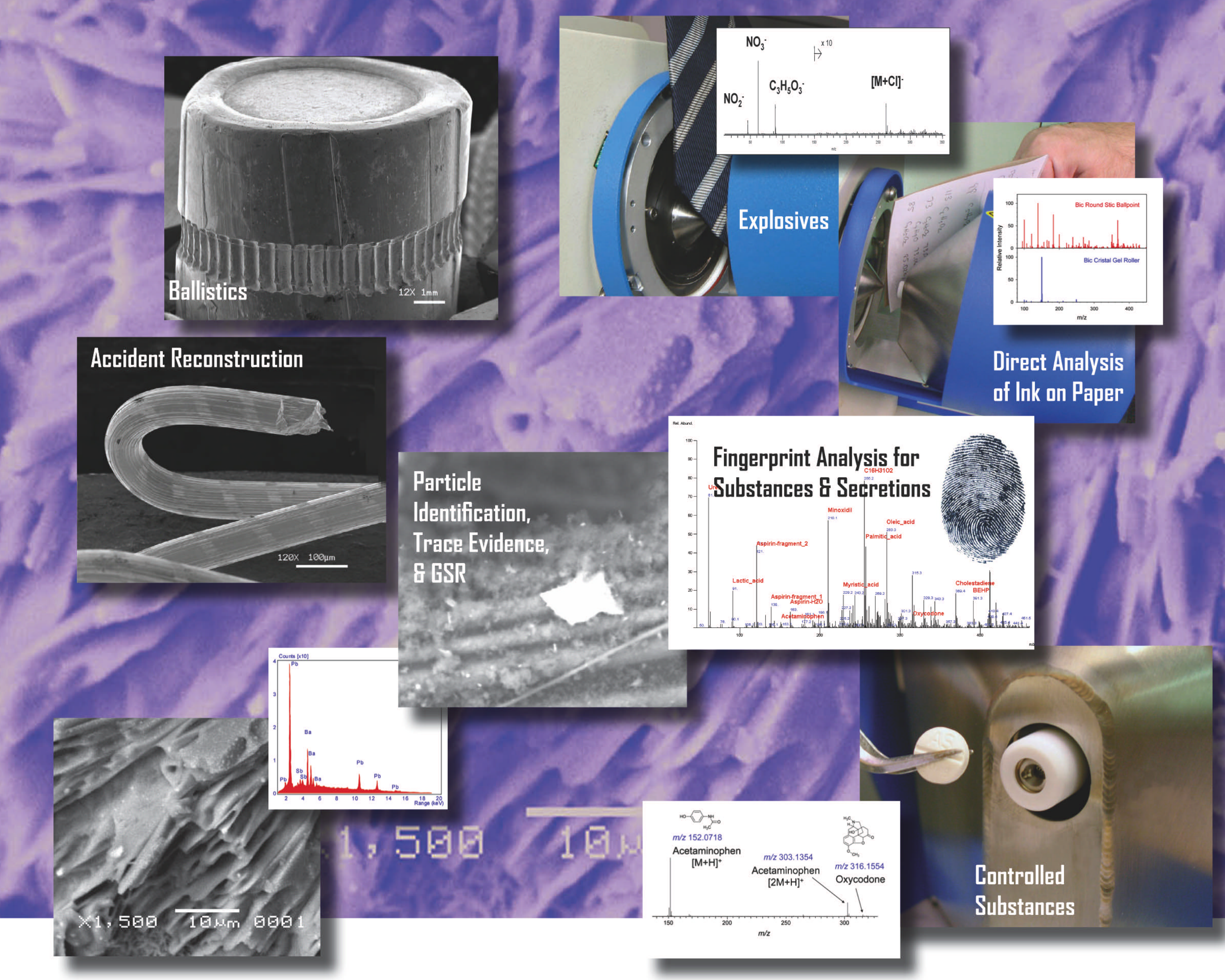


Figure 1: Countries with active nationwide offender DNA database programs (as of August, 2012). There are 44 countries worldwide, with over 40 million total profiles estimated to be uploaded. (Source: www.dnaresource.com)

Loci Commonly Used in Global Forensic DNA Databases

	CODIS (U.S.)	Europe	CODIS (proposed expansion)
Amelogenin	X	X	X
D18S51	X	X	X
FGA	X	X	X
D21S11	X	X	X
D8S1179	X	X	X
vWA	X	X	X
D13S317	X		X
D16S539	X	X	X
D7S820	X		X
TH01	X	X	X
D3S1358	X	X	X
D5S818	X		X
CSF1PO	X		X
D2S1338*	X	X	X
D19S433*	X	X	X
D1S1656		X	X
D12S391		X	X
D2S441		X	X
D10S1248		X	X
DYS391			X
TPOX**	X		X
D22S1045**		X	X
SE33**		X	X

Figure 2: Loci most commonly used in global forensic DNA databases, including the current CODIS set in the United States, which is also used by many other countries, as well as the set now used most commonly in Europe, and the proposed expanded CODIS set. Loci marked with an "*" are not currently required in the CODIS "core loci" but are commonly analyzed and uploaded as part of the most widely used multiplexes and are designated as "required" in the proposed expanded CODIS set. Loci marked with "**" are "highly recommended" but not required for inclusion by manufacturers according to the new CODIS recommendations.


Ballistics
12X 1mm
NO$_3^-$
x 10
NO$_2^-$
C$_3$H$_5$O$_3^-$
[M+Cl]$^-$
Explosives
Bic Round Stic Ballpoint
Bic Cristal Gel Roller
Relative Intensity
m/z
Direct Analysis of Ink on Paper
Accident Reconstruction
120X 100µm
Particle Identification, Trace Evidence, & GSR
Fingerprint Analysis for Substances & Secretions
Minoxidil
Oleic_acid
Palmitic_acid
Aspirin-fragment_2
Lactic_acid
Myristic_acid
Cholestadiene
BEHP
Oxycodone
Acetaminophen
Counts [x10]
Pb
Ba
Sb
Range (keV)
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where all countries could exchange data obtained by law enforcement officers, including DNA. In tandem with this effort, the European Network of Forensic Science Institutes (ENFSI) group made recommendations to member countries to utilize an expanded set of loci for DNA testing in an effort to minimize adventitious matches.[1,2]

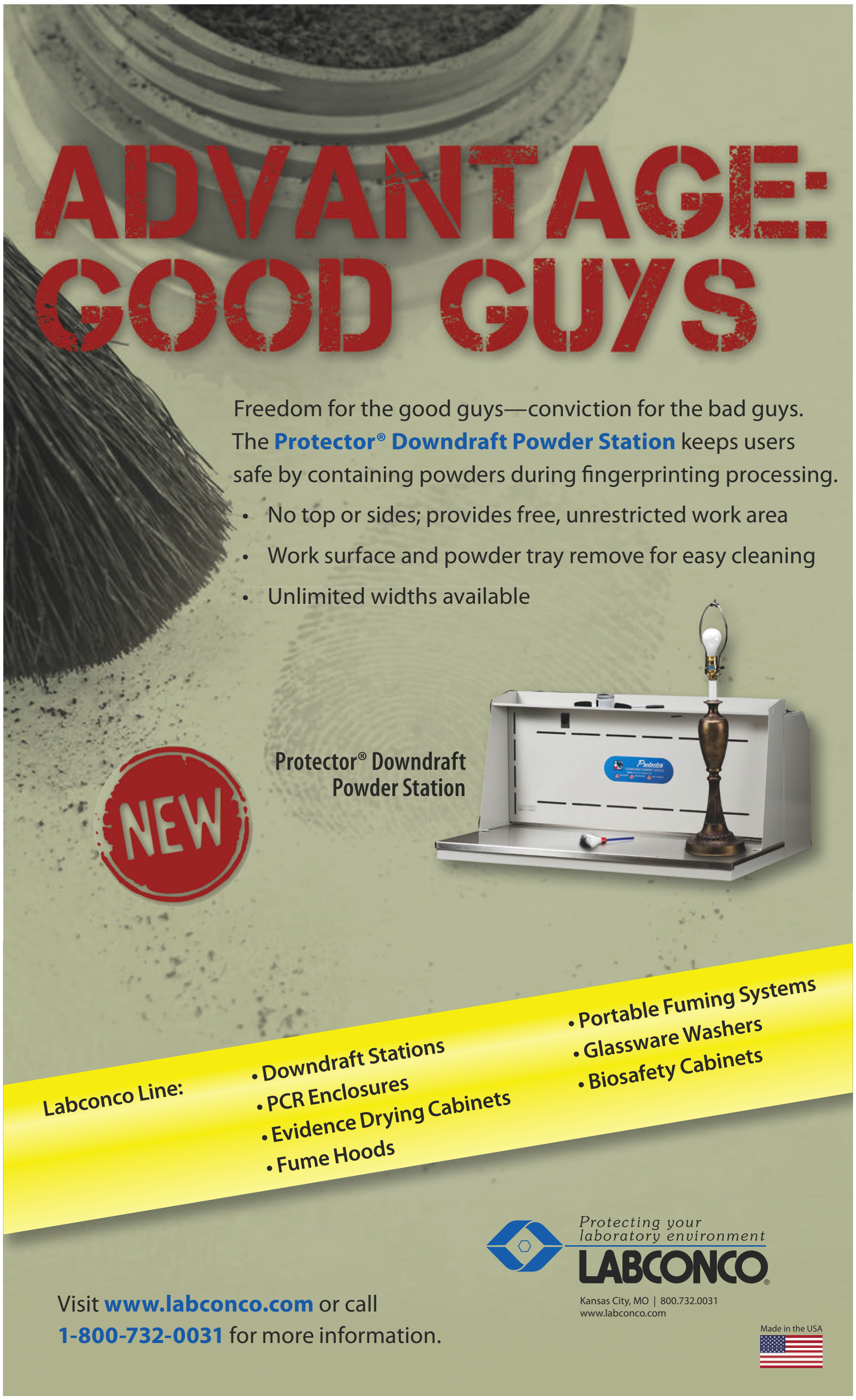
As the established countries continued to expand the tools needed to increase the utility of their DNA databases, additional countries pursuing national DNA database programs began to emerge in other regions, such as Eastern Europe, Asia, Latin America, and the Middle East. Fortunately, these new regions applied the lessons learned from the Prüm Treaty implementation and included larger loci sets as a requirement prior to establishing their programs. In many of these regions, representatives from DNA laboratories have worked together to determine loci standardization recommendations to ensure they create databases that can share information seamlessly within their region.

To date, forty-four countries have implemented nationwide criminal offender DNA database programs (Figure 1). The number of offender samples throughout the world is now over 40 million, and is expanding rapidly. Even with many countries in the world utilizing well established DNA databases, a significant increase of global samples is yet to come. By 2020 it is estimated that 75 countries will have national DNA database programs and many of the existing programs will be expanding legislative mandates to collect DNA from all convicted offenders and arrestees.[3] As these expansions are made, it is possible that world-wide offender samples could number in the hundreds of millions.

While the second and future wave DNA database countries have learned from the early adopters that loci standardization is important, a major problem still exists. The reality is that there are still many different loci sets throughout the world that are not interoperable, and when compared to each other a significant rate of adventitious matches may occur.[4]

The solution to addressing these concerns is for the world's DNA community to begin to adopt large sets of loci that are shared throughout the world. Most recently, the FBI formed the CODIS Core Loci Working Group that has published a set of recommendations to expand the STR loci set used in the United States (and many other countries) to include the world's most commonly used loci (Figure 2). These recommendations include 20 loci that are required and three loci that are highly recommended for inclusion by kit manufacturers in a single next generation multiplex.[5,6]

Newly recommended loci standards encourage reagent manufactures to develop larger, more powerful multiplexes to meet the expanded requirements. These new "global" multiplexes will create loci interoperability with



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other countries and therefore significantly improve cross-border data sharing efforts. Furthermore, they will provide each country with the confidence that no matter how large their own databases grow, adventitious matches will be less of a concern.

Technology Races to Meet the Needs of the Forensic DNA Community

The recent initiatives to expand international locus recommendations have crystallised the need for a new global multiplex system; however, the design of such a system, which must include all the necessary loci without sacrificing performance and processing capabilities, poses significant challenges.

Size Matters

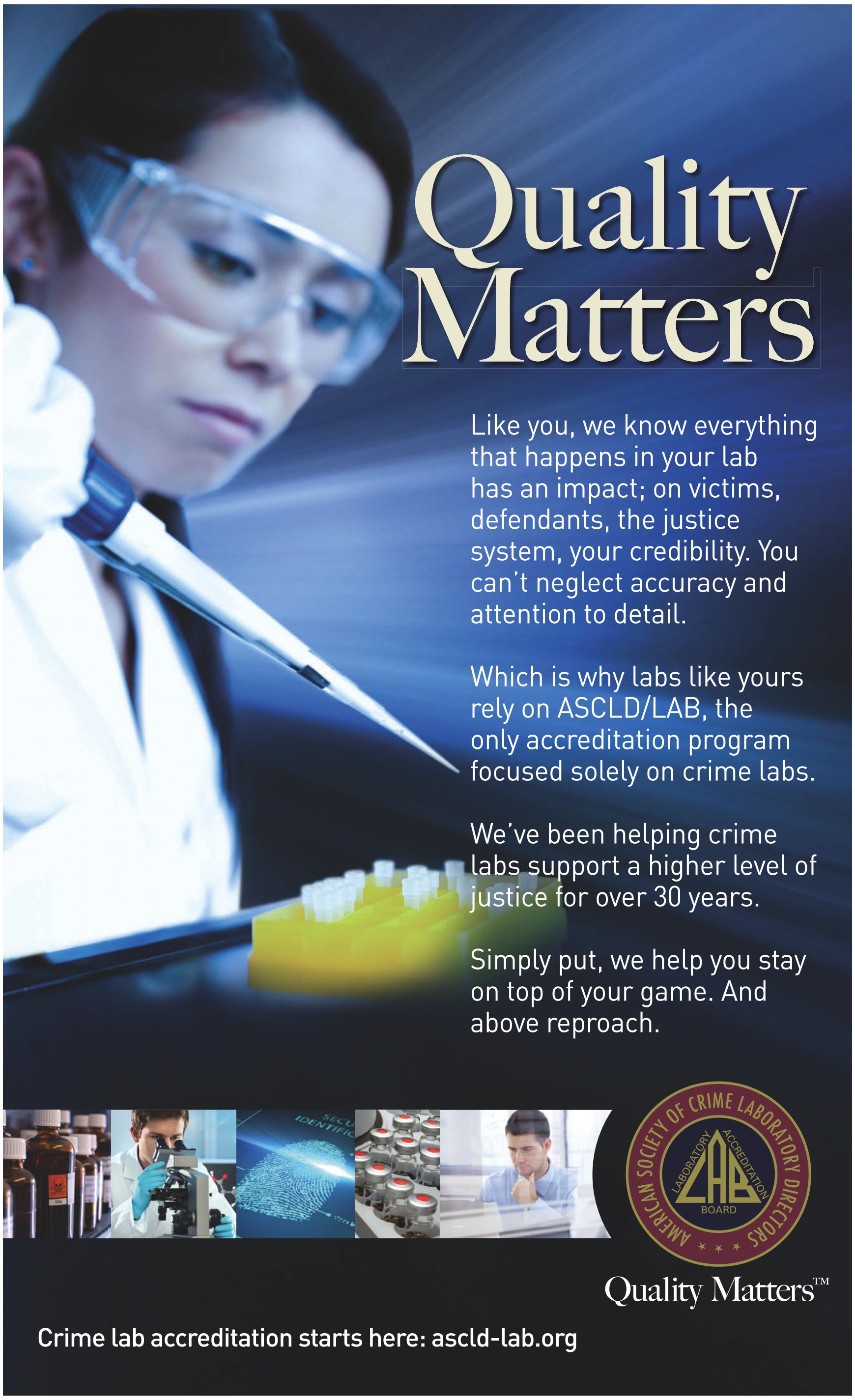
The first challenge relates to size and spacing. The new CODIS recommendations specify 20 "required" markers and an additional three classed as "highly recommended" for inclusion in a single multiplex. To accommodate all 23 markers utilizing the current maximum of five available dye labels without significantly increasing the size of some of the amplicons would be impossible. Technology such as mobility modifiers, which adjust the mobility of a locus and relocate it into a higher size bracket, can be useful to optimize spacing between loci; however, due to limitations on the number of these molecules which can be employed before hurting the multiplex's performance, these are not a viable option for significant repositioning of loci within the system.

The only way to achieve major relocation of loci with the restrictions imposed by a 5-dye system would be to redesign the primers to physically lengthen the amplicons. Changing the primer sequences in this way has a number of disadvantages, however, including a loss of concordance with data generated using the original primer sequences and the vulnerability of longer amplicons to the effects of degradation.

An added complication that puts pressure on the 5-dye model comes from the desire expressed by the forensic community to widen the marker ranges for established loci to better reflect the allele distributions revealed through the extensive databasing efforts of recent years. Wider marker ranges, when supported by an increase in the number of alleles within the associated allelic ladder, would enhance genotyping efficiency with fewer alleles being designated as "off-ladder." However, maintaining sufficient space between adjacent markers to facilitate clear and unambiguous genotyping in the majority of cases becomes increasingly difficult as each range is extended.

Application Demands

The second challenge revolves around developing a system



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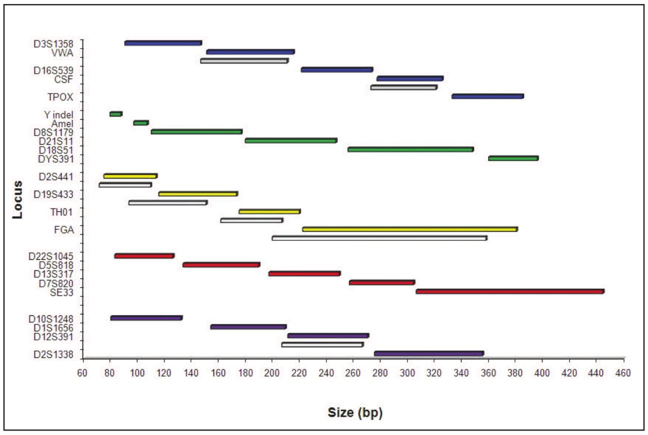

Figure 3: Locus configuration of the GlobalFiler Kits. The colored bars indicate the mobility of the amplicons while the grey boxes indicate the physical amplicon length before the application of mobility modifiers for seven of the loci. For ease of interpretation, all three gender determination markers are located in the green dye channel. For performance on degraded samples, ten STR loci reside completely below 220 base pairs.

that meets the fundamentally different needs of single-source and casework evidence samples. Single-source samples, such as those collected for DNA databasing or as casework reference samples, are generally of a predictable nature in that they are collected on standardised substrates (usually paper or swabs), yield high quantity, high quality DNA, are generally processed close to the time of collection, and are collected from a single individual. Casework samples are in contrast often complex and unpredictable in nature, present on highly variable substrates, yield low quantity and/or low quality DNA, are aged or environmentally exposed, and can contain more than one contributor.

Added to this are the very different processing environments required for these types of samples. Single-source samples are generally received in higher numbers and as such, efficiency and amenability to automation of processing and analysis are important if laboratories are to maximize throughput while minimizing laboratory personnel requirements. For casework evidence samples, performance is paramount. The multiplex must be able to yield robust results for a wide range of inhibited and degraded samples.

To address these requirements and challenges, Life Technologies has developed a new, expanded STR multiplex configuration. To overcome the issue of size and spacing, the introduction of a 6-dye chemistry enables all 23 of the loci listed in the CODIS recommendations to be incorporated into a single multiplex configuration. The availability of an additional dye channel together with the strategic use of mobility modifiers has enabled all 23 loci to be included with minimal adjustment to existing primer sequences, preserving amplicon length and maximizing concordance with existing datasets as much as possible (Figure 3).

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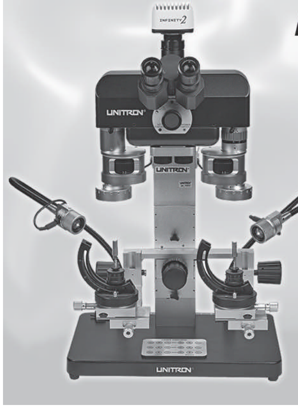

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The only loci for which the core primer sequences have changed compared to current kits are TPOX and DYS391. In both cases, only the reverse primer has been re-engineered, repositioning the loci in the longer size range of the multiplex while minimizing any impact on concordance. The enlargement of the TPOX locus was considered an acceptable compromise given that this locus has been downgraded from a "required" to a "highly recommended" locus on the CODIS marker list. In addition, the relatively low discrimination power associated with this locus means that any failure to perform under degraded DNA conditions would have minimal impact on overall information recovery.

The DYS391 locus is included to provide gender determination redundancy for Amelogenin Y-null individuals. There may obviously be a concern that positioning this locus in the longer size range may result in drop-out under degraded DNA conditions. To compensate for this possibility, an additional Y-indel locus has been included below Amelogenin to ensure accurate gender assignment, even for degraded samples.

The Impact

Over the next two years, as the United States and other countries around the world begin to adopt advanced STR multiplexes with expanded loci sets for forensic testing, a new era of DNA analysis will ensue. This should enable forensic analysts to achieve optimal results with all types of forensic samples and will allow more crimes to be solved, more quickly, with less adventitious database hits. Ultimately, this will enable the global law enforcement community to maximize the use of DNA as a crime fighting tool and continue to reaffirm DNA as the gold standard and most effective forensic tool available to law enforcement.

References can be found online at www.forensicmag.com/article/maximizing-power-forensic-dna-databases-next-generation-str-technology.

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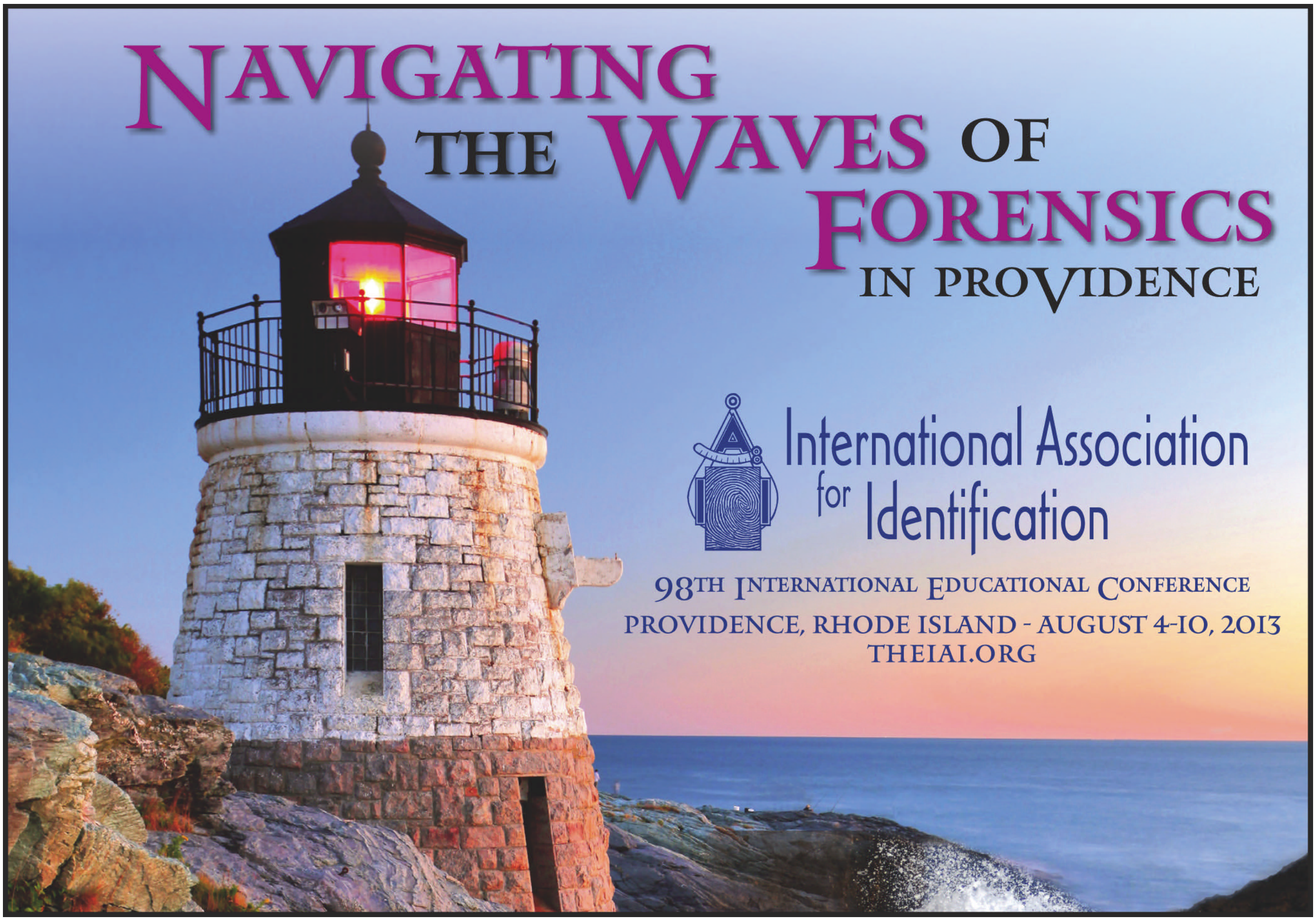
Nicola Oldroyd *is a Consultant Forensic Scientist at Life Technologies. She is an experienced forensic science professional with nearly 20 years in the forensic science industry. Life Technologies, 850 Lincoln Centre Drive, Foster City, CA, 94404*

Lisa Lane Schade*, MHR is the Director of Global Marketing for the Human Identification Business at Life Technologies. She is responsible for working with forensic DNA laboratories around the world to help define and execute the strategic direction for the Human Identification business.*



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Applying the New Science of Metaphors to Forensic Science Testimony

Using metaphors to explain concepts and data enhances the scientific testimony's impact, meaning, and memory-value.

Ronald K. Bullis, Ph.D., J.D.

> *All thinking is metaphorical.*
> Robert Frost, (quoted in Shibles, 1974)

Forensic scientists are increasingly required to testify about their findings and their professional conclusions.[1] To present clear and compelling testimony, forensic experts need more than their science training. They need effective and evidence-based communication skills. This article describes and illustrates why metaphors are such powerful vehicles for scientific testimony and presents a simple, but extremely effective method to offer clear and compelling forensic science testimony.

Forensic scientists are like translators. They must "translate" scientific procedure and opinion in ways that both educate and persuade jurors. Legal scholars recognize that narrative elements, such as metaphors, effectively negotiate those two world-views, language, and goals.[2]

Science, especially neuroscience, also tells us that metaphors function as significant cognitive tools for data interpretation and decision-making.[3] Metaphors have climbed out of literature courses and into court

Neuroscience and Using Forensic Metaphors

Metaphors associate dissimilar concepts across areas of the brain associated both with affect and cognition. The images used in metaphors connect to our own images to form powerful and persuasive cognitive associations. First, they collect neurons together to form constellations of images. "Neurons that fire together, wire together" is the most famous adage in neuroscience.[4] It means that images and metaphors that ignite memories, thoughts, and feelings bundle together to form constellations of much more powerful thoughts. Because this bundling of neurons takes place across a wide area of the brain, the impact of the metaphor increases geometrically.

The following trial excerpt[5] depicts how one forensic scientist explained the role of DNA to the jury under direct testimony.

> **Prosecutor:** ...But what is DNA? I mean, we—we know it's out there. What is it?
> **Forensic scientist:** …It controls how you develop and function. You inherit half your DNA from your mother and half from your father, and the inherent DNA will stay the same throughout your lifetime.

Can you spot the metaphor? "Controls" is not a scientific analysis or description of how DNA works. "Controls" is a metaphor for how DNA works. It's a metaphor because it connects two different images. We "control" our car. We "control" our TV remote. When the scientist used "controls," he tapped into all jurors' images of "control," so that DNA doesn't just equal "control." The metaphor equals all the jurors' expectations, memories, and motivations for controlling. The use of "control" now clusters with every other neuron connected to "control" in the juror's mind. The well-placed metaphor goes viral in the mind of jurors in seconds.

Metaphors are powerful testimonial tools for three reasons. First, metaphors can transform how jurors "frame" or understand and consider trial issues.[5] Metaphors provide the cognitive infrastructure into which ideas and data will be stored and understood. Jurors use metaphors as "frames" into which they "fit" evidence and testimony. Forensic scientists who use forensic metaphors marshal neuroscience to clearly and convincingly define the role and significance of their testimony.

Second, metaphors "reframe" images and incite thinking "outside the box."[6] Metaphors, in connecting dissimilar images, expand and "morph" the meaning of both images. Forensic scientists may urge jurors to think in new and different ways. After all, jurors consider facts from different perspectives offered from different parties in court. In the "control" metaphor above, the jurors' minds pave new pathways for the significance of DNA as well as the significance of DNA evidence for their particular case. Metaphors are perfect vehicles by which to "try on" evidence using different images.

Third, metaphors enhance meaning and meaning enhances memory.[7] Metaphors enhance meaning and the more meaningful a concept, the more memorable it is. The more a juror understands about the importance of scientific testimony, the more they will remember it. Ideas connected to images make it easier for our brains to remember names, numbers, faces, even events. The more jurors integrate forensic testimony into their own concepts and understanding, the more they will recall that testimony in their deliberations.

Applying Metaphors for Clear, Compelling Testimony

Scientific testimony can seem unfamiliar and esoteric to jurors. A scientist who tries to explain science with more science piles confusion upon confusion. After all, the scientist has invested years in education and training to learn his or her protocols, techniques, and scientific judgment. Probably every juror has heard of DNA, but it is unwise to assume that jurors know its structure and function—let alone its particular significance to a particular case.

Yet, jurors are expected to assess the credibility of forensic scientists, to assess the value of their testimony to the case, and to prioritize scientific evidence to the case at hand. Also, jurors may labor under information from forensic science-inspired TV shows and movies that may or may not be accurate or applicable for their case.

Metaphors help. They neither "dumb-down" infomation nor change the science. They render technical information in a concise, clear, and compelling manner—if metaphors are used properly.

Research shows that the most effective metaphors are both familiar to the jury and appropriate to the issue at hand.[8] The next two sections explain and apply these factors.

Using Familiar Metaphors

Effective metaphors place familiar faces on unfamiliar testimony. Unfamiliar scientific testimony is a problem. A solution is to explain science with evocative, familiar metaphors, such as in the following exchange.[9]

> **Prosecuting Attorney:** Now, could you explain what DNA is?
> **Scientist:** DNA stands for deoxyribonucleic acid. And basically DNA can be thought of as a blueprint for your body just as you have a blueprint to build a house that tells you where the walls and windows should go.

In using the "blueprint" metaphor to answer the question, this forensic scientist explained the function and importance of DNA evidence in a single sentence. While jurors may not know either the scientific name for DNA or its specific function, they know what a "blueprint" is. If the scientist makes metaphors both familiar and fit the issue, they will be meaningful and memorable to the jury.

Using Relevant Metaphors

Relevant metaphors fit the right issue in the right case at the right time. Irrelevant metaphors confuse the testimony and confuse the jury. Here, the forensic scientist explains a concept that was a significant factor, both at trial and subsequent appeal.[10]

> **Attorney:** Now, you testified that you followed the protocol. What does that mean in layman's terms? I'm not—
> **Scientist:** Right. Just like you have a recipe for telling you how to cook a—make a cake, we have recipes which tell us how to conduct the DNA testing. It is called a protocol then. It is a recipe.
> **Attorney:** And that's what you followed. Is that correct?
> **Scientist:** Yes.

All scientists know the importance of protocols, but jurors may not. Calling a protocol a "recipe" evokes the connection between a protocol and a familiar set of important steps—following a cake recipe for example. The procedures are verifiable, clear, uniform, and measureable. A recipe is neither experimental nor arbitrary. Likewise, a protocol is the product of testing to verify its reliability and validity. Moreover, a number of jurisdictions follow the same protocol. Therefore, it is easy to verify its effectiveness in large-scale studies.

Finally, the "recipe" metaphor evokes a "tasty" product, yielding a satisfying, accurate result. Instead of belaboring the minutia of protocols, the well-placed metaphor drives home the protocol's characteristics and its significance cogently and compellingly.

Continuing Education for Forensic Scientists

We use metaphors every day. Every time we give or accept flowers, daydream about a new car or a new home, or watch commercials on TV we create and apply metaphors. We use metaphors to describe movies, vacations, and sometimes, our bosses! Forensic scientists use forensic metaphors in a specific way. Creating and applying forensic metaphors is both an analytical and imaginative process. This is a learned process.

Here are a few hints on creating effective metaphors.

1. Clearly define the point of the scientific testimony. Will it describe the reliability of the method? Will it have to define scientific concepts (such as DNA or protocols) or will it have to describe the method of data collection?
2. Now, let your mind wander a little ("free association" as Freud called it).
3. Use "like" or "as" to link one image with another. For example, "blood pattern analysis is like…"
4. Make a list of possible metaphors.
5. Finally, use analytical skills to determine which metaphor is most familiar and appropriate to use with a particular issue, a particular case, and a particular jury.

Conclusion

Neither the importance of scientific data nor its relationship to the trial issue are immediately recognized or valued by jurors. The best science in the world is lost when jurors misunderstand its content or significance. Using metaphors to explain concepts and data enhances the scientific testimony's impact, meaning, and memory-value. Metaphors don't change the science or dumb it down. They make science clear and compelling.

References can be found online at www.forensicmag.com/article/applying-new-science-metaphors-forensic-science-testimony.

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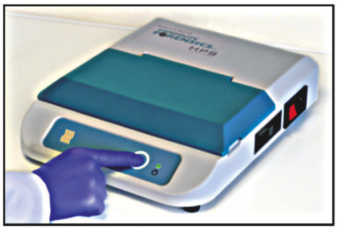

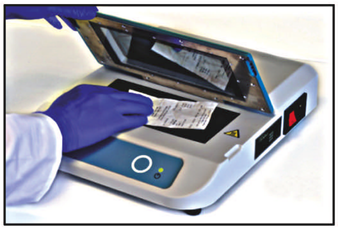

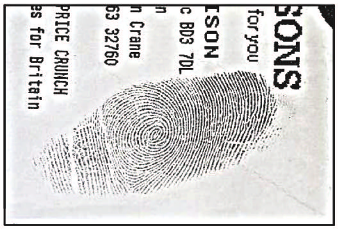

Mobile Forensics Fights to Stay Ahead

Law enforcement groups are staying ahead of criminals' ability to conceal information with the use of new data extraction tools.

Tim Studt

Handheld digital data extraction forensic devices are becoming essential tools for law enforcement agencies to rapidly and reliably obtain data from the wide variety of mobile phones and smart devices now available. Detective Dan Morrissey, the Gang Intelligence Supervisor for the Sacramento, California Sheriff's Dept. was a beta-tester of Cellebrite's recently introduced handheld UFED Touch, and a long-time UFED user.

The editors of *DFI News* recently asked Det. Morrissey about his use of this device:

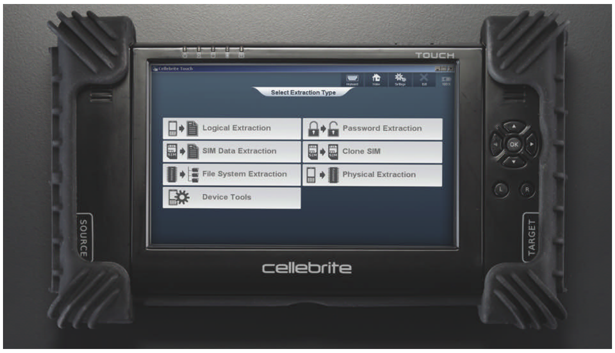

Figure 1: The UFED Touch.

DFI News: How have you used this device to solve a particularly complex crime?

Det. Morrissey: We were recently investigating a rather large criminal organization and during the investigation, it was determined that some high-visibility street suppression would be useful in identifying unknown gang members who were known to travel in a specific geographic region. During the operation, one of the subjects was found to have more than five mobile phones on him. Several of the phones had little or no information on them, but two of the devices did. With the phones previously seized, and the phones recovered from this operation, an additional fifteen members were confirmed to have a nexus to the gang.

DFI News: What features of the UFED Touch do you particularly like?

Det. Morrissey: First of all, the device is significantly faster when extracting media content than previous devices we've used. This allows for a shorter time on target when completing examinations in the field, and the ability to do more examinations in a laboratory setting as well. The fact that it's Windows-based, also allows for instant examination of the source data in the field.

DFI News: Are you able to stay ahead of criminals by finding viable evidence? Are they getting smarter in their ability to conceal information?

Det. Morrissey: The criminal's ability to gain access to technological equipment and use it for nefarious means is a formidable challenge.

When it comes to criminals and digital evidence, criminal skill sets are as wide ranging as their crimes. Some criminals may be more cautious and use prepaid phones they can throw away when they are done using them. Others will password protect their devices or delete as much of their usage as they can before an arrest. Some criminals will utilize a combination of these items and actively seek out ways to make their device useable, without becoming a liability to them.

DFI News: How fast is the technology environment changing/expanding?

Det. Morrissey: Technology is expanding at a tremendous rate. The types and releases of individual software operating systems have seemed to slow down, but the production of new devices seems constant.

DFI News: What are the most difficult issues you have to contend with in this area?

Det. Morrissey: The two biggest issues we encounter are password protected phones and supported devices. We keep our handheld extraction devices updated, because we continually come into contact with new phones. It's not uncommon to find criminals in possession of prepaid devices the day or week they were released.

Tim Studt *is the Editorial Director of DFI News.*
tim.studt@advantagemedia.com

the Safety guys

Vince McLeod, CIH

You've Got Me under Pressure

A facility support technician was called to repair a leaking valve in the compressed gas cylinder storage room. Upon entering the room he found the leaking valve near the floor under one of the large gas cylinders near the back corner. Kneeling down with his tools he started in on his assigned morning project. Within minutes he noticed he was breathing hard, getting a headache, and feeling tired. Remembering his long list of things to do that day, his first thoughts were to push ahead and hurry to finish this job. Fortunately, he yielded to his instincts that something was not quite right and tried to recall what these symptoms meant from that safety training long ago. He stood up and was hit with an overwhelming feeling of dizziness. He steadied himself and then left the room to seek assistance.

> Moving cylinders from the vendor supply truck to the storage area is often done haphazardly or with a cavalier attitude.

This close call turned out to be the result of a leak in the carbon dioxide gas delivery system. The much heavier than air carbon dioxide gas had settled near the floor displacing the normal air and its oxygen. Colorless, tasteless, and odorless, the greatly increased concentration of carbon dioxide might have easily gone un-noticed except for the symptoms produced. Had the technician tried to finish the valve repair job, a few more minutes of breathing the heavily concentrated carbon dioxide probably would have resulted in unconsciousness and possibly death.

Forensic laboratories, just like many research laboratories, use a variety of compressed gases. These can range from the classic inert gases like carbon dioxide (used in the scenario above), helium, and argon to the highly flammable acetylene and oxygen used for gas chromatographs and high performance liquid chromatography. So in this issue the Safety Guys offer a few basic tips on safe use of compressed gas cylinders and preventing accidents and close calls.

How do you know what you are dealing with?

Compressed gas is loaded into, transported in, and used from heavy walled metal cylinders. These cylinders come in all sizes and shapes from little one pound "lecture" bottles to railroad tank cars. The size most commonly used in forensic laboratories and facilities are the eighty pound cylinders, referred to as "K" sized bottles. They are about eight inches in diameter and forty eight inches tall and can contain a wide array of compressed gases.

The requirements for manufacture of cylinders are detailed in Title 49 Code of Federal Regulations, Part 178, Specifications for Packaging.[1] For our purpose we just want to point out that all cylinders should have permanent stamped markings on the shoulder. These should show the DOT specification, the proper service pressure (in gauge pounds per square inch, psig), the manufacturer's symbol and serial number, the owner's symbol, and most importantly for safety, the date of the initial qualification test and any subsequent tests. Cylinders need to be re-tested every five years. In addition to the permanent markings, the cylinder should also have an identifying label on the shoulder indicating the cylinder's contents.

Basic Rules for Safe Handling of Cylinders from Acceptance to Zero (gas left)

What follows here is a condensed set of basic guidelines applicable to all gas cylinders. The Compressed Gas Association publishes an excellent reference[2] as well as a large number of specific pamphlets with more detailed information. Additional resources that we use a lot are Prudent Practices[3] by the National Safety Council and the Canadian Compressed Gas Safety Web site.[4] An attempt to cover all the different classes of compressed gases is beyond the scope of this article but we will gladly respond to readers' special concerns perhaps with follow up articles if interest is high.

Step 1: *Before accepting or receiving compressed gas cylinders perform a quick inspection.* All cylinders should be shipped with regulators removed and safety caps in place. Check cylinders for heavy rust or pitting and refuse any questionable ones. Check the certification date(s). Finally, make sure all cylinders have a durable label that cannot be easily removed and that clearly identifies the contents.

Step 2: *Transport compressed gas cylinders with care.* Since we are only moving cylinders from the vendor supply truck to our storage area or direct to the laboratory or facility use area, this step is straight forward but often done haphazardly or with a cavalier attitude. Compressed gas cylinders should only be transported using wheeled carts designed for this purpose. Make sure safety caps are in place and cylinders are secured to the cart. When moving multiple cylinders, do not allow them to bear against or strike each other. Finally, know the route you will travel and remove all potential obstacles. If lift gates or ramps are used, enlist a spotter or helper before moving cylinders.

Step 3: *Develop specific safe handling and use procedures for your compressed gas cylinders.* Depending on the specific gas used, safety procedures can become quite complex. For example, extremely hazardous gases may require dedicated ventilated storage cabinets, safety interlocks, and elaborate alarm systems. Here are a few basic ground rules to follow. When transporting, ensure all cylinders are properly secured. Common methods include chains, straps, and specialty clamps. Install a proper regulator when in use and when not in use remove the regulator and install safety caps. Maintain adequate ventilation and temperature control for the area. Finally, close the valve and release the pressure in the system at the end of each use.

Step 4: *Don't forget about storage areas.* Most sites have a designated area for compressed gas cylinder storage, particularly large facilities and those with high volume use. These areas are often relegated to the back closet and overlooked. General safety considerations include many already mentioned above such as securing cylinders to prevent tipping, falling, and knocking together; having regulators removed and safety caps installed; and maintaining good ventilation and temperature control. There are a few important additions however. First, the area should be locked and secured against theft and vandalism. Preferably, the cylinder storage area is located away from emergency exits. The next most important issue is storage by compatibility along with proper separation between hazard classes. Be sure to check with local fire codes that specify distances and quantities allowed. Clearly mark all empty cylinders and segregate these from full cylinders as well. Empty cylinders should be moved and handled with the same care as full ones and returned to the vendor promptly.

Summary

Taking the time to develop and implement a compressed gas safety program for your research or production facility will go a long way in preventing accidents and potential tragedy. Most fixes and corrections are low cost and easily installed and maintained. Compared to the costs associated with the alternatives, it is hard to argue against a good compressed gas safety program.

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Vince McLeod *is an American Board of Industrial Hygiene Certified Industrial Hygienist and the senior IH with the University of Florida's Environmental Health and Safety Division. He has 24 years of experience in all facets of occupational health and safety and specializes in conducting exposure assessments and health hazard evaluations.*

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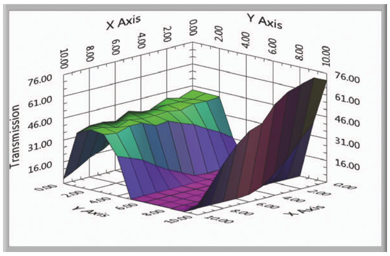

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Most wanted

Answers to Facility Issues

Lou Hartman

The Goldilocks Principle: Getting Your Engineering Systems Just Right

Utility systems that support forensic science need to hit the mark and be, as Goldilocks said, just right. Design systems that are too big and you've invested money that could have been used elsewhere. Too complex and you'll spend more money maintaining them. Skip the energy conserving features and you'll spend more on utility bills indefinitely.

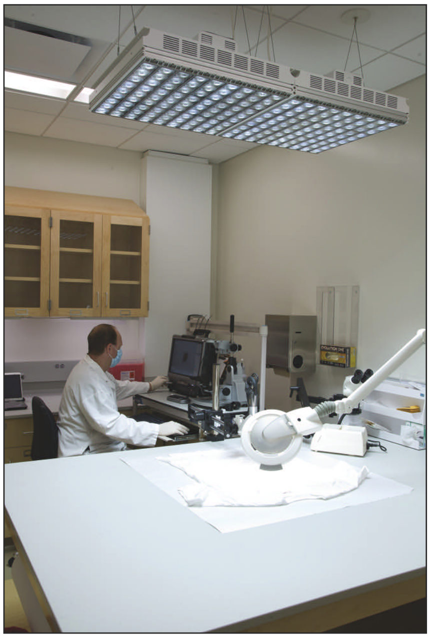

Figure 1: An LED exam light at the Johnson County facility. © Joe Atchity

This lab is too hot.

Visit an older lab facility and almost without exception, you'll find the existing utility system having difficulties supporting the direct equipment needs as well as struggling to maintain the environmental conditions necessary for proper instrument function. One of the largest strains on the building electrical and cooling systems is instrument rooms packed full of equipment with extensive electrical demands and cooling requirements. Undoubtedly fume hoods and biological safety cabinets have been added and somehow have been made to work, and most often only sort of made to work compromising the safety of the workspace. In general, in older laboratory facilities the lab utility systems are inadequate; quite often substantially inadequate.

This lab is too cold.

Examine many new lab facilities and you'll find that the pendulum has swung too far in the opposite direction. Don't be surprised if you find that the actual peak electrical or cooling requirements are one-third to one-half of what was installed. Buying the infrastructure which supplies two to three times more than what you need to support your building is expensive and an investment that could have been better directed to improving energy efficiency. The systems that you will see in many new laboratory facilities are also unduly complicated. Forensic labs are some of the most complex buildings that a city, county, and/or state government facility staff will need to maintain, so it is important to have systems that are not overly complicated. It is important to keep it as simple as possible.

These labs are just right.

Here are a few concepts from two recently completed facilities, the Tucson Police Department Crime Laboratory and the Johnson County Kansas Sheriff's Office Criminalistics Laboratory. Both buildings are about 60,000 square feet and house full service forensics laboratories. (Read more about both of these stunning new facilities in the August/September article, "The New Face of Forensic Science.") There are many ways in which the systems in these two new facilities are just right.

Hybrid Ventilation Systems

For decades lab designs have called for the installation of separate ventilation systems for offices and laboratories. If you would like a just right facility, combine them into a single system. A single hybrid ventilation system is easier to build, saves significantly on initial cost, simplifies maintenance, reduces energy consumption, and provides better ventilation in the office areas. Design a hybrid properly and you'll also build in greater standby capabilities without adding additional expense.

Chemical Fume Hoods

Carefully select the type of fume hood you will use for your project. Old technology fume hoods are highly inefficient. To make such hoods more efficient, designs routinely incorporated elaborate systems of controls to throttle back unnecessary air flows bringing both added expense and maintenance issues to the table. Newly designed chemical fume hoods offer many containment performance improvements. By using either restricted sash opening or low face velocity (60 fpm) designs the amount of exhaust in hood systems can be reduced by up to 75% of older hood designs. With these lower flow rates, complicated variable volume controls may not be needed adding an additional perk to the use of such hoods.

Energy Capture

Capture and reuse as much energy as possible from the exhaust air stream. Even in the most efficient laboratory facilities, energy is being wasted by the evacuation of conditioned air out of the building. The most effective system available for capturing this lost energy uses a "total energy (enthalpy) wheel" that transfers both sensible and latent energy in both heating and cooling modes between the air being brought into the building and the conditioned air being exhausted. (It is important to evaluate chemical usage since enthalpy wheels may not be compatible with all chemicals.) A detailed review of chemicals used at the Johnson County facility confirmed that the use of an enthalpy wheel was appropriate and it became a key component in an overall energy saving strategy of the building, which netted a 48% overall energy reduction in heating and cooling costs.

Heat Pumps

If you're in a region that has balanced heating and cooling seasons you may want to consider ground source heat pumps, often also referred to as a geothermal system. At the Johnson County Criminalistics Laboratory, a well field of 118 five-hundred-foot-deep wells is connected through recirculating piping to central heat pump units that produce chilled water, heating hot water and hot domestic water. Using the well field improves energy efficiency and also eliminates the use of over 1,000,000 gallons of water annually when compared to conventional cooling towers.

Sun Energy and Day Lighting

Take advantage of the sun. While the use of photovoltaics may or may not be economical depending on where you are located and what you pay for electricity, controlling, capturing, and using the sun's energy for day lighting is always important. A good example is the Tucson Police Department Crime Lab. Tucson's desert location benefits from over 350 sunny days a year. Control and capture of the sun's energy is an important part of the design of this facility, allowing for day lighting of even central core areas of the building. Day lighting strategies that combine high performance windows with shading and light shelves which bounce daylight further back into the building were used on both the Tucson and Johnson County projects. This strategy was combined with lighting controls to turn off fluorescent lighting when not needed providing additional value in the cost savings realized by decreased dependence on electrical lighting.

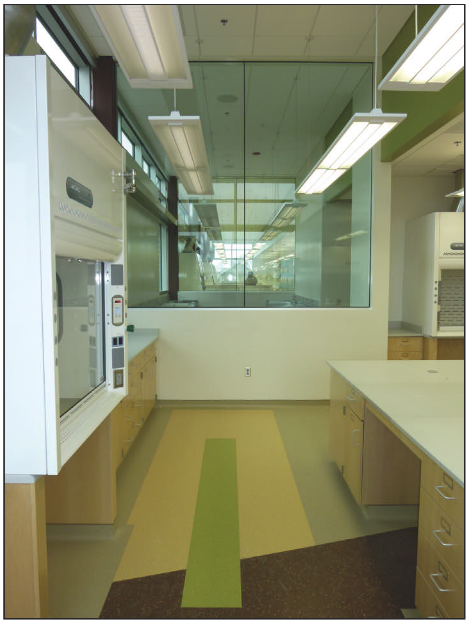

Figure 2: Sensors automatically turn off lights when there is enough daylight that they are not needed.

The type of lighting is also an opportunity to both improve the work environment and to reduce energy consumption. High efficiency pendant mounted fluorescent light fixtures provide a highly effective way to light a space, but also create an environment with a bright ceiling and a more open feel. LED task and exam lights are great ways to provide higher localized light levels without using a lot of power. Last, the simple forethought of siting a building appropriately to take advantage of natural light should be a key component to your initial design thoughts.

While a laboratory isn't a bowl of porridge, like in the story of *Goldilocks and the Three Bears*, laboratories can be too hot (lacking infrastructure), too cold (over-engineered), or just right. Just right labs, such as the Tucson Police Department Crime Laboratory and the Johnson County Sheriff's Office Criminalistics Laboratory find the right balance. They include such elements as correctly designed and sized heating and cooling systems, energy capture devices, and harness the energy of natural day lighting. And then they all lived happily ever after.

Lou Hartman *is a Principal and Sr. Mechanical Engineer with Crime Lab Design, which provides full A/E services for forensic and medical examiner facilities around the world.*

Digital forensic insider

John J. Barbara

Windows 7 Registry Forensics: Part 7

REGISTRY FORENSICS – SECURITY IDENTIFIERS

Security Identifiers (SIDs) are unique alphanumeric character strings of variable length that are assigned during the log-on-process to each user on a stand-alone system or to each user, group, and computer on a domain-controlled network. Windows uses SIDs instead of usernames. For instance, when a username and password are entered, Windows must verify that the password for the username matches what is stored. The Registry is queried to determine what SID is associated with the username. From that point forward, Windows then grants or denies access and privileges to resources based on Access Control Lists (ACL), which use SIDs to uniquely identify users and/or their group memberships. SIDs can be resolved to users. For a non-domain logon, user authentication is carried out locally in the Security Account Manager (SAM). When a user logs onto a domain, the authentication occurs in the active directory of the domain controller. Essentially, SAMs are security databases which contain hashed passwords and usernames. They are also a Registry Hive.

1. SECURITY ACCOUNTS MANAGER (SAM):

- HKLM\SAM\Domains\Account\Aliases\Members
- HKLM\SAM\Domains\Account\Users

SAM is not accessible through the normal Registry view on a live system. After exporting the Registry, it can be accessed using a tool such as Registry Viewer. Information such as the user name, logon count, last logon time, last password change, last failed logon, and so on are stored in the user account(s). The SAM will also list one or more SIDs.

2. SECURITY IDENTIFIERS (SIDs):

- HKU\
- HKLM\Software\Microsoft\WindowsNT\Current Version\Profilelist

SIDs are located in both of these Keys. User SIDs can be found under the value "Profilelist" as Subkeys (which were created at the time a user logged onto the system). The value "ProfileImagePath" will list the path to that particular user's profile. At the operating system level, SIDs identify accounts beyond question. A multi-user system would look something like this:

- HKU\.DEFAULT
- HKU\S-1-5-18
- HKU\S-1-5-19
- HKU\S-1-5-20
- HKU\S-1-5-21-1116317227-3122546273-4014252621-1000
- HKU\S-1-5-21-1116317227-3122546273-4014252621-1000_Classes
- HKU\S-1-5-21-1116317227-3122546273-4014252621-1003
- HKU\S-1-5-21-1116317227-3122546273-4014252621-1003_Classes

The first four Keys are the System Accounts and are generally the same from computer to computer. HKU\.DEFAULT contains global user information. HKU\S-1-5-18 pertains to the "LocalSystem Account." HKU\S-1-5-19 is used to run the local services and is the "LocalService Account." HKU\S-1-5-20 is the "NetworkService Account" that is used to run the network service(s). The other Subkeys are the unique SIDs which are associated with individual users who have logged onto the system. Their interpretation is as follows:

- "S" identifies the string as a SID.
- "1" is the version of the SID specification.
- "5" is the identifier authority value.
- "21-1116317227-3122546273-4014252621" is the domain or local computer identifier and differs from computer to computer since it corresponds to unique individual user accounts.
- "1000" is the Relative ID (RID). Any group or user not created by default will have a RID of 1000 or greater.
- "1000_Classes" contains the per-user file associations and class registration.
- "1003" is Relative ID (RID) of another user on the same system.
- "1003_Classes" contains the second user's file associations and class registration.

REGISTRY FORENSICS – FOLDER STRUCTURES

There are a number of default folders with default locations that are defined by Windows. Although a user can create and move folders virtually anywhere on a hard drive, they normally do not change the default folder locations. However if the user is trying to obfuscate information, the default locations can be changed to point to other storage locations. When a user opens a folder, resizes the folder window, closes the folder, and reopens it later, Windows

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remembers the folder dimensions. Additionally, a user may have different screen resolutions for their desktop which they normally customize.

- HKEY_USERS\.DEFAULT\Software\Microsoft\Windows\CurrentVersion\Explorer\User Shell Folders
- HKCU\Software\Microsoft\Windows\Current Version\Explorer\User Shell Folders
- HKCU\Software\Microsoft\Windows\Current Version\Explorer\Shell Folders

The first two Keys list the various default paths to many locations of potential forensic interest, such as a user's "Cookies," "Desktop," "Favorites," "History," "My Pictures," "My Video," "Recent Items," and "Start Menu." For instance, the default path for a user's "My Pictures" and "My Video" is "%USERPROFILE%\Pictures" and "%USERPROFILE%\Videos" respectively. Similarly, the third Key lists the paths to the various locations in each of the individual user directories starting from the root directory ("C:\Users\{User Name}\My Pictures" and "C:\Users\{User Name}\My Videos" for the above examples). These can be changed to point to another location, possibly a hidden directory, or a hidden partition where probative information could be stored.

- HKCU\Software\Microsoft\Windows\Shell\Bags\1\Desktop\ItemPos1024x768x96(1)

A user may use more than one desktop and may have different files, folders, applications, or shortcuts on each of those desktops. This Key lists the user's desktop screen resolution under the "ItemPos" value (e.g. "ItemPos1024x768x96(1)"). The "Data" value for a particular screen resolution will contain the user's links to applications (e.g. "Powerpoint.lnk), applications on the desktop (e.g. Autoruns.exe), the names of files and their extensions (e.g. Registy.pdf), and the names of folders.

(Note: Software tools mentioned in this column should not to be considered as an endorsement of those tools by *Forensic Magazine* or by the author. Prior to purchasing commercial tools or obtaining freeware tools, investigators and examiners should research those that are available to determine which best meet their technical and operational performance parameters.)

***John J. Barbara** owns Digital Forensics Consulting, LLC, providing consulting services for companies and laboratories seeking digital forensics accreditation. An ASCLD/LAB inspector since 1993, John has conducted inspections in several forensic disciplines including Digital Evidence. John is the General Editor for the "Handbook of Digital & Multimedia Forensic Evidence" published by Humana Press. jjb@digforcon.com.*

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10. Owner: Advantage Business Media, LLC, 100 Enterprise Drive, Suite 600, Box 912, Rockaway, NJ 07866-0912 **11.** Known Bondholders, Mortgagees, and Other Security Holders Owning or Holding 1 Percent or More of Total Amount of Bonds, Mortgages, or Other Securities: none **12.** Tax Status: The purpose, function, and nonprofit status of this organization and the exempt status for federal income tax purposes has not changed during preceding 12 months

13. Publication Title: FORENSIC MAGAZINE **14.** Issue Date for Circulation Data Below: Aug/Sept 2012

15. Extent and Nature of Circulation:	Average No. Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
a. Total Number of Copies *(Net Press Run)*	8,572	7,381
b. Legitimate Paid and/or Requested Distribution		
(1) Outside County Paid/Requested Mail Subscriptions Stated on PS Form 3541	6,031	5,051
(2) In-County Paid/Requested Mail Subscriptions Stated on PS Form 3541	0	0
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(4) Requested Copies Distributed by Other Mail Classes Throught the USPS (e.g.	0	0
c. Total Paid and/or Requested Circulation (Sum of 15b. (1), (2), (3) and (4))	6,031	5,051
d. Nonrequested Distribution		
(1) Outside County Nonrequested Copies Stated on PS Form 3541	1,071	691
(2) In-CountyNonrequested Copies Stated on PS Form 3541	0	0
(3) Non-Requested Copies Distributed Through the USPS by Other Clases of Mail	0	0
(4) Non-Requested Copies Distributed Outside the Mail	1,289	1,500
e. Total Nonrequested Distribution (Sum of 15d (1), (2), (3) and (4))	2,360	2,191
f. Total Distribution (Sum of 15c and e)	8,391	7,242
g. Copies Not Distributed	181	139
h. Total (Sum of 15f and g)	8,572	7,381
i. Percent Paid and/or Requested Circulation (15c divided by f times 100)	71.9%	69.7%

16. Publication of Statement of Ownership for a Requestor Publication is required and will be printed in the October 2012 issue of this publication.

17. Signature and Title of Editor, Publisher, Business Manager, or Owner

Gail Kirberger, Associate Director Audience Development (Signed)

Advantage Business Media Statement of Digital Circulation

1. Publication Title: FORENSIC MAGAZINE	Average No. Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
Printed Circulation as reported on PS Form 3526-R, Line 15A	8,572	7,381
Digital Circulation	3,850	5,043
Total Circulation	12,422	12,424

Gail Kirberger, Associate Director Audience Development (Signed)

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how it works

A Fast and Accurate LC/MS/MS Method for the Analysis of Bath Salts

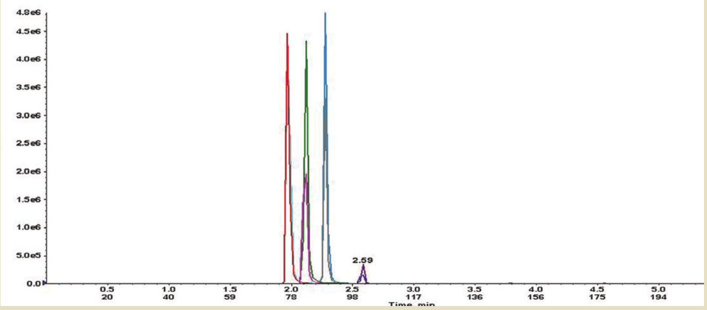

Figure 1: Bath Salts Analysis
Column: Kinetex 2.6 µm C18
Dimension: 50 x 3.0 mm
Mobile Phase: A: 10 mm Ammonium formate
B: Methanol with 0.1% Formic acid
Gradient: 5-100 % B in 3 min, hold 1 min
Flow Rate: 500 µL/min
Detection: MS/MS (API 5000™)

Problem: Over the past several years, there has been a dramatic rise in the use and abuse of a group of synthetic chemicals known on the street as "bath salts." Bath salts belong to a class of compounds known as synthetic cathinones and are structurally and chemically related to amphetamine. In October 2011, several bath salts (mephedrone, methylone, and MDPV) were classified as Schedule I drugs, making them completely illegal for sale in any form. The non-regulated bath salts, however, are still widely available for purchase both online and over-the-counter under such names as "Ivory White," "Vanilla Sky," and "Cloud Nine." The term "Bath Salts" actually encompasses a broad range of more than 100 synthetically derived compounds, and chemists working for illegal drug manufacturers are constantly developing new variants in order to bypass the laws intended to prevent their illicit sale and distribution.

Forensic testing labs face the ongoing challenge of developing fast and accurate analytical methods to keep pace with the constant development of these new "designer drugs." In this brief communication, we present a fast and effective LC/MS/MS method for the analysis of some common bath salts.

Solution: Due to its sensitivity and specificity, liquid chromatography coupled with tandem mass spectroscopy (LC/MS/MS) is the method of choice for many forensic and clinical testing methods for the analysis of illicit drug substances. At the heart of LC/MS/MS is the HPLC column, where the analytes in the sample matrix are separated prior to moving into the MS detector where identification and quantitation occurs.

Kinetex® core-shell technology represents the latest advances in LC columns, delivering short run times and high column efficiencies on any HPLC or UHPLC system. Using a Kinetex 2.6-micron C18 50 x 3.0 mm column, a method was developed for the three illegal bath salts (methylone, mephedrone, and MDPV) scheduled as illegal, and also methamphetamine, which is typically also found in conjunction with these other drug substances. This method demonstrates baseline separation for all four peaks with a total run time of less than four minutes and an acquisition window of less than one minute (Figure 1), making it an excellent candidate for multiplex systems.

To maximize sample purity and column lifetime, as well as increase signal response, sample matrices (usually urine) can be cleaned up and concentrated using Solid Phase Extraction (SPE). SPE can effectively remove many of the endogenous interferences from sample matrices that can confound analyses, particularly when targeting analytes at very low levels. SPE sorbents from the Strata™-X-Drug family have been specifically designed for use in drugs of abuse testing and can be relied upon to simply and effectively clean up and concentrate samples prior to LC/MS/MS analysis.

MRM Transitions and MS Settings:

Q1	Q3	msec	Name	DP	EP	CE	CXP
276.2	205.3	10	MDPV	80	10	15	13
208.1	160.2	10	Methylone	80	10	25	13
178.1	160.2	10	Mephedrone	80	10	25	13
150.1	119.0	10	Methamphetamine	60	10	20	14

For more information, visit www.phenomenex.com.

Who says you Can't do that?

Dick Warrington

Crime Scene Checklists: Value in the Report

Over the course of your career as a Crime Scene Officer you're likely to encounter a wide variety of cases. In some cases, scenes can be chaotic, and it can be easy to miss a step. But no matter the situation, it's your responsibility to process the scene thoroughly, consistently, and professionally.

One of the best tools I know of is a checklist. Checklists are used by professionals in many fields, including aviation, medicine, and construction. Written checklists help the professionals in these fields control the complex routines they need to follow to do their jobs correctly. While you'll have to spend some time up front creating the checklist, it will save you time in the long run. After all, you're going to have to fill out a report at the end of each case. If you do a good job setting up your checklist, you'll have all the information you need for your report by the time you finish processing the scene. Your narratives will be very short, since most of the information you'll need will be in your checklist. Even more important, your checklist will help you avoid mistakes that can cost you a case.

In order to be worthwhile, the crime scene checklist needs to be comprehensive yet easy to use. It should cover everything from the time you're called to the scene to the time the scene is released. The more detailed you make it, the better. Before you create your checklist, you need to think ahead. Think about all of the information, evidence, etc. you need to consider for any case, whether it's a robbery or an assault or a homicide. Review the forms you fill out for your cases. Those reports will show you the kinds of information you need to collect.

As you go through this process of analyzing your crime scenes and reports, you'll find that there's some basic information you're going to need no matter the crime. Use this information as the starting point for your checklist. Then customize your form to create a checklist that is appropriate for each specific type of crime scene. You can use Microsoft Word Form Fill or any of the many available software programs on the market to create a template that can then be modified as needed.

Keep in mind that the purpose of the checklist is to help you collect the information you need and keep track of it. Set up your checklist so that it's easy to fill out. Use boxes that can be filled in or checked off as you go along. Make the form easy to read. Ideally, it should also follow logically with the way you process a scene.

Let's take a look at some basic information that should be on every checklist.

1. Identifying information. Provide boxes to fill in this information: Department Name; Offense; Date; Case #; Location; Time Notified; Notified By; Authorized By; Time Arrived; Victim's Name, Address, and Phone #.
2. Information about the Scene. Note that some information needs boxes, some requires circling Y (yes) or N (no): 1st Officer at Scene; Scene Security: Was Scene Secured Y or N; Method Secured: Officer, Barrier Tape, Other; Scene Security Log Started Y or N (if needed); Scene Entry Log Started Y or N (if needed); Search Warrant Y or N.
3. Weapons Present. For each weapon present include the following information: Type (gun, knife, etc.); Location; Information Found on the Weapon.
4. Scene Processing. Evidence Recovered: Y or N; Evidence Custody Sheet Y or N; Location of all Evidence. List of all Evidence Collected at Crime Scene Y or N; Date and Time Recovered.
5. Items Processed at Scene. Fingerprinting Y or N. Location where Processed. Date and Time began. Date and Time ended. DNA Y or N. Location where Processed. Date and Time began. Date and Time ended. (Note: information should be recorded for each item processed.)
6. Trace Evidence. Sample list: Blood, hair, fibers, stains, glass fragments, soil/dirt, toolmarks, liquid, other. For each item, indicate Y or N, then describe the item, including the location where found.
7. Shoe and Tire Tracks. Shoe Tracks: Y or N. Describe, Location. Photographed: Y or N. Microstatic lifting: Y or N. Tire Tracks: Y or N. Describe, Location. Photographed: Y or N. Casted: Y or N.
8. Photo Log: Y or N (if required by department).
9. Leaving the Crime Scene: Date, Time, Was it Secured: Y or Turned over to the Victim.

As you can see, this checklist covers the key areas you need to remember to control your scene. Modify this list as needed to create your own master checklist. The effort you put in now will be well worth what you get out of it. In the next issue of *Forensic Magazine*, I'll discuss some ways to customize your master checklist for specific crime scenes.

Dick Warrington *is in research and development and a crime scene consultant and training instructor for the Lynn Peavey Company. Dick can be reached at dwarrington@peaveycorp.com.*

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